MP MASTER
MA32418

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Notes

Model 3000 FET V-O-M

DELTA PRODUCTS, INC.

P. O. BOX 1147 GRAND JUNCTION, COLORADO

MODEL 3000 SPECIFICATIONS

DC Volts Accuracy	± 2% FS Nominal ± 1% FS
DC Amps Accuracy	± 2% FS Nominal ± 1% FS
AC Accuracy 20 CPS - 500 CPS Sine Wave	± 3% FS Nominal ± 2% FS
Ohms Accuracy 10% - 90% of scale	± 5% ABS
Input Impedance	10 Megohms ± 1%
Frequency Response	20 CPS to 20 KC ± 1% on .3 volt scale 20 CPS to 500 CPS ± 1% on all other scales

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MODEL 3000 SPECIFICATIONS

DC Volts Accuracy	± 2% FS Nominal ± 1% FS
DC Amps Accuracy	± 2% FS Nominal ± 1% FS
AC Accuracy 60 HZ	± 3% FS Nominal ± 2% FS
Ohms Accuracy 10% - 90% of scale	± 5% Absolute
Input Impedance	10 Megohms ± 1%
Frequency Response	20 HZ to 20 KHZ ± 1% on .3 volt scale 20 HZ to 400 HZ ± 1% on 1 volt scale 20 HZ to 300 HZ ± 1% on 3 volt, 10 volt, and 30 volt scale 20 HZ to 200 HZ ± 1% on 100 volt and 300 volt scale 20 HZ to 100 HZ ± 1% on 1000 volt scale

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DELTA MODEL 3000
FET VOM

GENERAL

The Model 3000 VOM is intended for use as a general purpose meter for laboratory and field maintenance of electronic equipment. Circuit design and packaging is such as to provide a meter which is virtually immune to electrical damage with the active section designed around an integrated circuit operational amplifier. The meter is placed in the feedback loop of the operational amplifier providing excellent linearity on both AC and DC scales and eliminating calibration drift caused by changes in the active elements. An ohms current regulator has been incorporated into the design to provide for minimum adjustment when switching scales and, in addition, gives protection to semiconductor devices in circuits under test. As the ohms regulator provides a maximum voltage of .3 volts and a maximum current of 30 ma, the meter will not damage any reasonable power level semiconductor. Owing to the protection provided by the regulated ohms section, semiconductors cannot be checked by reading forward and reverse resistance on the ohms scales.

METER OPERATION

Battery Maintenance

Circuit design is such as to produce minimum battery drain and will provide a battery life of 200 - 400 hours in normal use. Battery drain when operating on volts and amps is approximately 2 ma and rises to 35 ma when switched to the ohms position. As a consequence of the higher battery drain in ohms position, life will be shortened appreciable if the meter is left in this position for prolonged time periods.

Battery load is slightly unequal and provision has been made for checking the batteries having maximum drain. To check battery condition, switch meter function switch to + DC volts and set the range selector switch to the 10 volt range. Touch meter input probe to mounting screw on rubber foot located below function selector switch. Batteries should be changed whenever the reading falls below 4.5 volts. In emergencies, the meter may be used with battery voltages down to 4 volts, if range selector is set to provide readings at half scale or below (i.e. 5 volts or less input on 10 volt scale, 15 volts or less on 30 volt scale, etc.). Batteries should be checked periodically and removed in the event of prolonged meter storage.

When replacing batteries, carefully observe polarity to insure proper operation. The meter uses six Type AA zinc carbon cells which may be purchased at any drug or hardware store. Higher cost and longer life batteries, such as alkaline or mercury cells may be employed if desired.

Measurement of AC or DC Voltages

Turn meter to proper function, short meter leads and turn zero adjust control to achieve a zero reading on DC and a minimum or null reading on AC (AC null may occur slightly above zero due to hum pickup. This will not appreciably affect reading accuracy.)

Measurement of AC or DC Voltages Continued

Set range selector for proper voltage range or, if voltage is unknown, start with selector switch in the 1000 volt position. Connect meter leads to circuit under test and turn range selector switch to achieve a reading as high as possible for maximum accuracy. If meter deflects downscale, change function selector from + DC to - DC, or from - DC to + DC. Use extreme care when measuring voltages, particularly when measuring power supply or line voltages. Any voltage in excess of 30 volts should be considered as potentially lethal and must be approached with caution. If the meter is used in areas where high level RF is present, shielded leads should be used with approximately 100K series resistance at probe tip.

Resistance Measurements

The Model 3000 VOM has the capability of providing extremely accurate resistance readings. To achieve the maximum inherent accuracy, it is suggested the following procedure be employed:

To adjust zero, turn function selector to ohms position and range switch to R x 1K, short leads and adjust "zero adjust" control to give a zero reading on meter. With meter leads open, adjust "ohms adjust" control to give a full scale or ∞ reading. To determine lead and clip resistance, turn range switch to R x 1, and short leads together, this reading (typically 0.2 ohm) should be subtracted from all low resistance readings for maximum accuracy. Do not re-zero meter on the low ohms scales, or accuracy will be degraded.

Current Measurements

The Model 3000 VOM is equipped to read current levels up to 300 ma by converting the current into a full scale voltage of .3 volts. Precision resistors are used for this function, and to prevent damage to precision resistors, care must be taken that the meter is not connected directly across a source of voltage while the function selector switch is in the DC amps position. Correct lead polarity must be employed to obtain upscale readings with the input lead connected to the + source and the common lead connected to the - polarity of the circuit. As a .3 volt drop is required for full scale readings, this should be taken into consideration whenever this magnitude of voltage drop is critical.

CIRCUIT DESCRIPTION

Impedance Conversion Amplifier

This section performs the function of converting a high impedance input signal into a low impedance signal without appreciably changing the voltage swing or the zero reference level. Referring to the circuit in Figure 1, operation of this section is as follows;

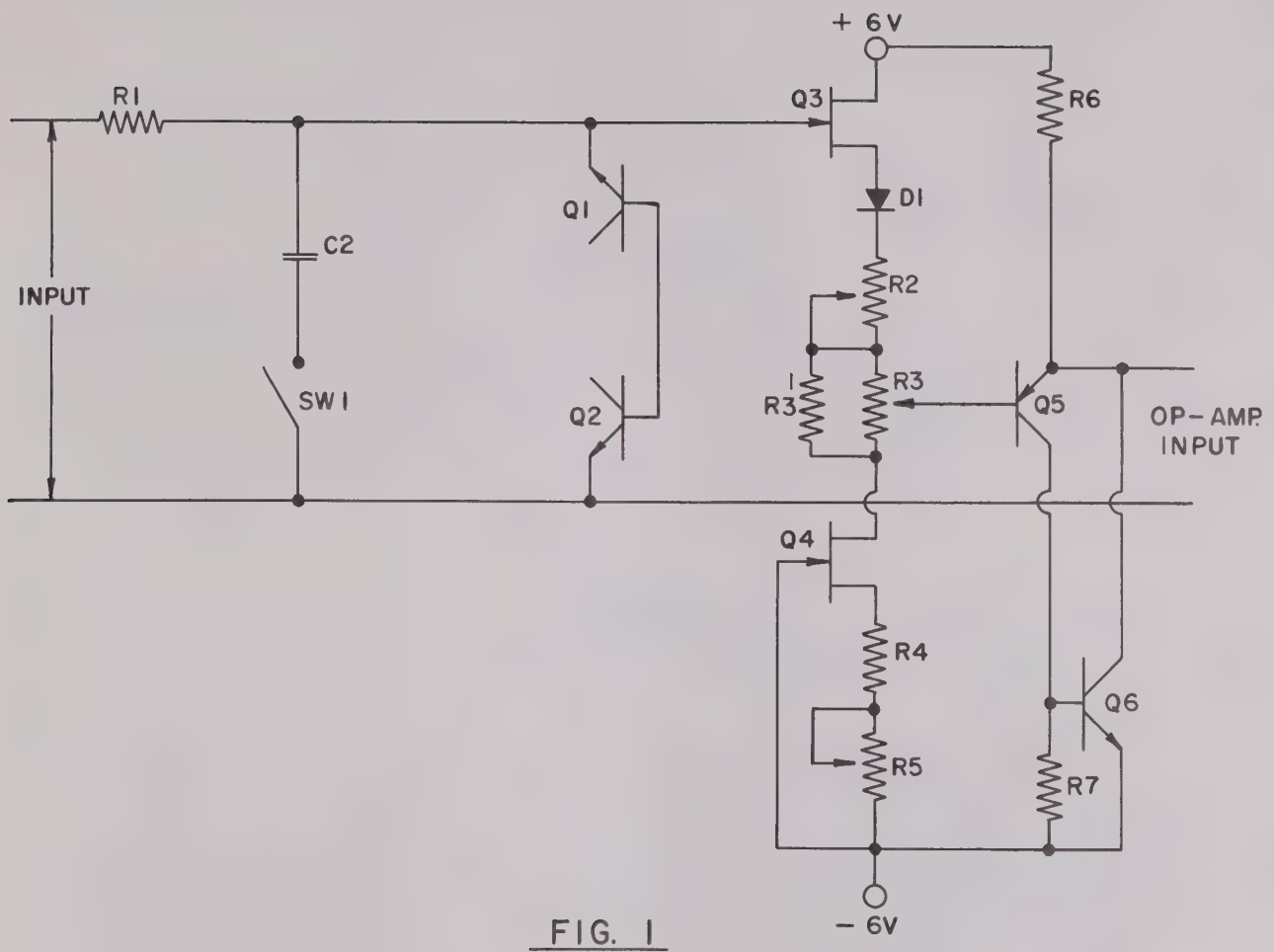


FIG. 1

R1, C2, Q1, and Q2 serve as an input filter and clipper. When SW1 is closed (all positions except AC) an RC filter is formed by R1 and C2 eliminating errors produced by stray pickup. Q1 and Q2 operate as a low capacity double anode zener to protect the succeeding circuitry from damage caused by over voltage.

Q4 operates as a constant current regulator for Q3 and the current level is set by R5 to give a value at which both Q4 and Q3 exhibit a near zero temperature coefficient. R2 and R3 are zero adjustments, with R2 serving as a course zero and R3 as a front panel adjustment whose maximum range is set by R3. Q5 and Q6 operate as a feedback pair to provide a low output impedance with low temperature sensitivity. Diode D1 is used as a temperature compensating element to give compensation for the small temperature variations introduced by Q5 and Q6. R6 and R7 are used as bias and stabilization resistors to give uniform performance with variations in transistor parameters.

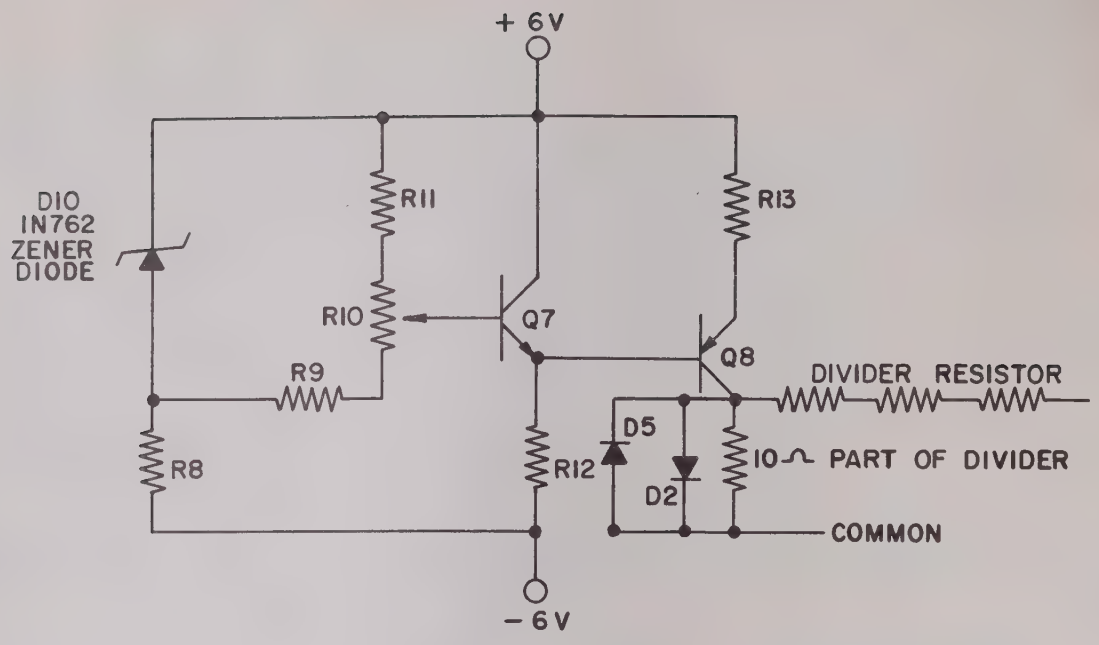


FIG. 2

Ohms Regulator

Referring to Figure 2, operation of the ohms regulator circuit is as follows;

Current is fed through the zener diode by R8, establishing approximately a 6 volt drop across the 1N762. R9, R10, and R11 form the elements of an adjustable voltage divider with the output of R10 (front panel ohms adjust control) fed to Q7 which operates as an emitter follower. The output of Q7 supplies a reference voltage to Q8 which is connected as a constant current regulator with the input voltage and the value of resistor R13 establishing a current of 30 ma. As Q7 is a NPN transistor and Q8 is a PNP transistor, they form a temperature compensated regulator system.

Operational Amplifier and Metering Circuit

The operational amplifier and metering circuit is connected as shown in Figure 3 and 4.

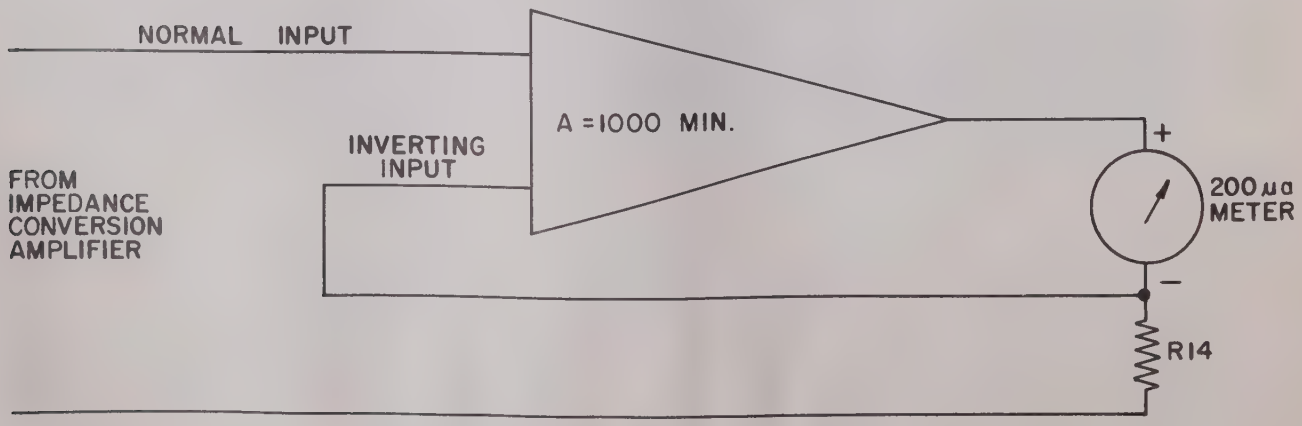


FIG. 3

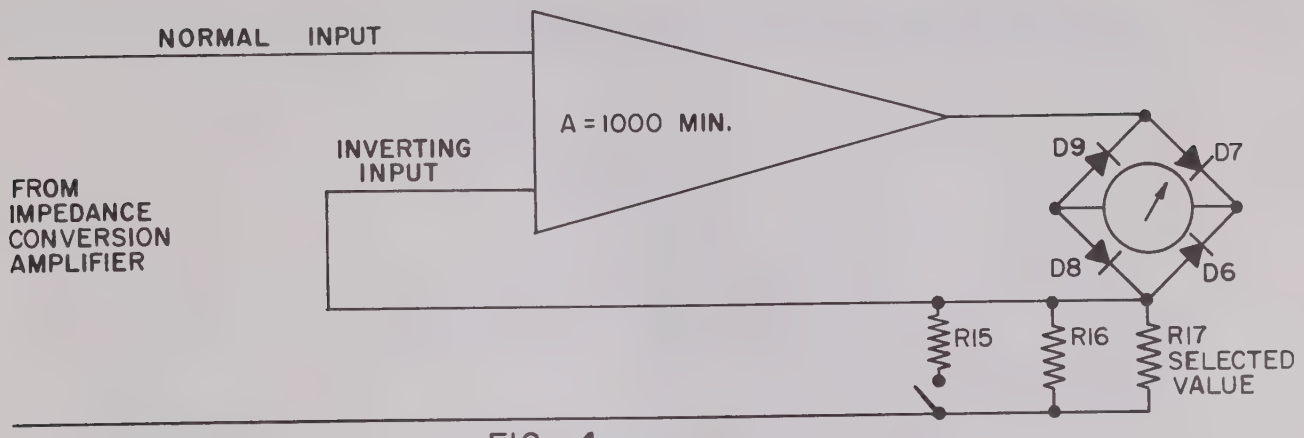


FIG. 4

As the operational amplifier (basically a high gain wide band DC amplifier) has an open loop gain of 1000 minimum and a closed loop gain of approximately 2, it may be stated that the output current will represent the input voltage to an accuracy better than .2%.

As the feedback loop is closed after rectification on AC (see Figure 4) diode non-linearity and energy gap effects are completely eliminated. The only requirement on AC is to correct for the fact that the meter reading is in RMS and the metering circuit would normally give an average reading. To correct for the difference, the feedback resistor R16 is shunted by R15 to give an 11% higher reading (average = .637 of peak, RMS = .707 of peak, $\frac{.707}{.637} = 1.11$).

Input Divider

To simplify wiring complexity, a multiple use divider is employed in the Model 3000 meter. On AC and DC scales, this divider presents a constant 10 megohm input impedance and gives minimal loading to any circuit. As the divider directly handles AC signals, some errors will occur at higher frequency due to distributed capacity of resistors and switching circuits. For maximum frequency response, the meter should be used in the .3 volt position with an external compensated attenuator being employed if necessary. Typical accuracy is within 1% to 20 KC on the .3 volt scale, but falls off drastically on other scales to approximately 1% error at 500 cycles worst case. A separate detector for RF may be employed with the meter, or a similar probe may be employed for wide band audio application if desired. The meter would, of course, be set on DC volts for this application (see Figure 5).

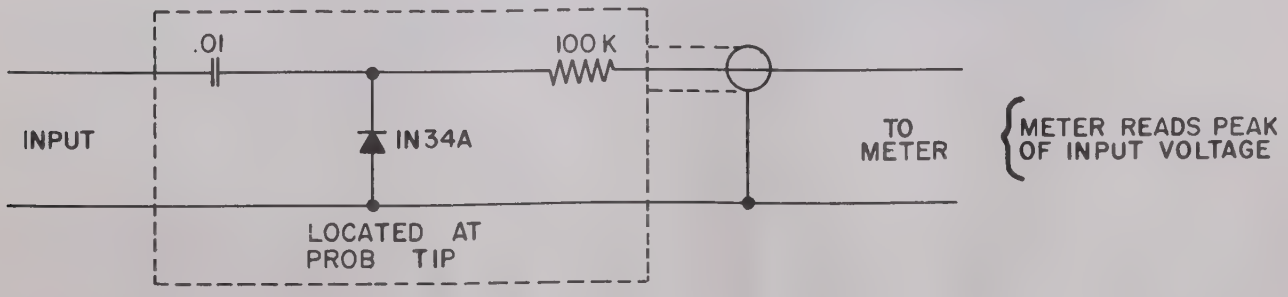


FIG. 5

Input Divider Continued

In the DC amps position the divider is connected as a shunt resistance whose value varies from 1 ohm on the 300 ma range to 10 megohms on the .03 ua range (see Figure 6).

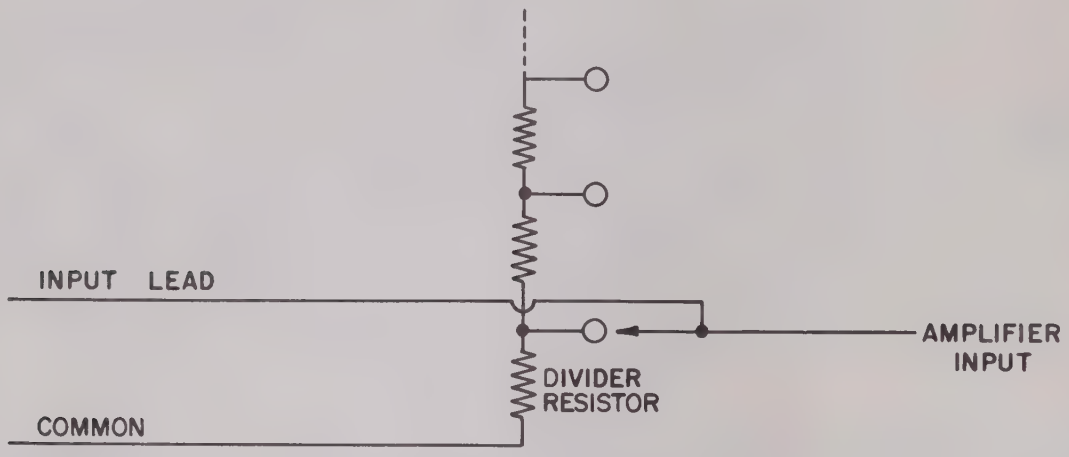


FIG. 6

In the ohms position the divider operates as a series resistance element from a .3 volt source with the resistance varying from 10 ohms to 10 megohms (see Figure 7).

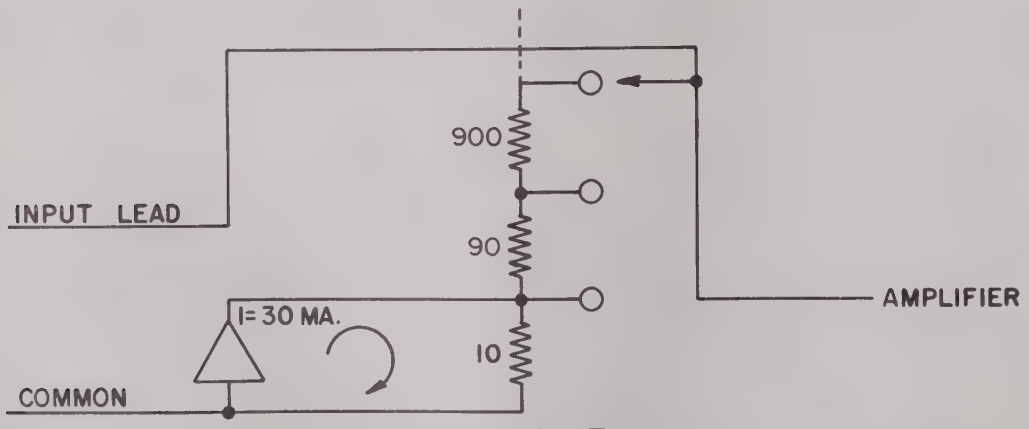


FIG. 7

POWER SWITCHING CIRCUIT

To reduce switch complexity, a switching circuit consisting of a rotary switch and a diode connected, as shown in figure 8, has been employed.

Power Switching Circuit Continued

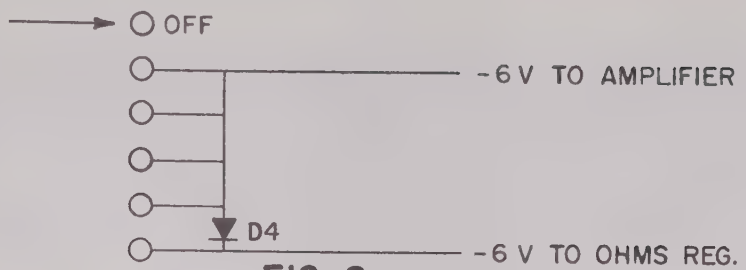


FIG. 8

Operation is as follows; Diode D 4 serves to block the - 6 volts from the ohms regulator in all positions except ohms, and allows both the amplifier and the ohms regulator to function in the ohms position.

PART REPLACEMENT

In general, parts damaged in service may be replaced with equivalent types. (See Parts List for value and tolerance). Semiconductors must be replaced with the same type number to maintain proper performance. In the event that one of the field effect transistors is replaced, adjustment of the trimmer potentiometers may be necessary to set these potentiometers. Proceed in accordance with the Adjustment of Zero Center and Zero Range Potentiometers section of the manual.

ADJUSTMENT PROCEDURE

The "ADJUSTMENT OF ZERO CENTER AND ZERO RANGE POTENTIOMETERS" section is divided into two procedures; the first requiring a D.C. voltmeter, capable of reading less than 1.0 volt, and the second requiring no test equipment. Use whichever method applies to you.

ADJUSTMENT OF ZERO CENTER AND ZERO RANGE POTENTIOMETERS WITH A VOLTMETER

(1) Set the zero adjust potentiometer, located on front panel, to its center position (5 turns from either end of travel).

(2) Set R2 (located on printed circuit board close to zero adjust potentiometer) to the mid-position of its travel.

(3) Set the function selector on the front panel to the AC position.

(4) Connect a D.C. voltmeter across R3' (1 K, brown-black-red-gold, located on printed circuit board, directly behind R2).

(5) The D.C. voltmeter should show a positive (upward) deflection. If it shows a negative deflection, reverse the voltmeter leads across R3'.

(6) Adjust R5 (located next to the ohms adjust) for a 0.4 volt reading on the D.C. voltmeter.

(7) Disconnect the D.C. voltmeter.

(8) Adjust R2 until the FET VOM meter reads 0.

Calibration is now complete.

ADJUSTMENT OF ZERO CENTER AND ZERO RANGE POTENTIOMETERS WITHOUT A VOLTMETER

(1) Set the zero adjust potentiometer, located on front panel, to its center position (5 turns from either end of travel).

(2) Set R2 (located on printed circuit board close to zero adjust potentiometer) to the mid-position of its travel.

(3) Set the function selector on the front panel to the +DC position.

(4) Unsolder both the brown and orange wires connecting to the meter terminals.

(5) Locate the black test lead. Connect one end to the meter terminal, where the brown wire was connected.

(6) Connect the opposite end of the black test lead to one side of R3' (1 K, brown-black-red-gold, located on printed circuit board, directly behind R2).

(7) Locate the 10 K (brown-black-orange-gold) resistor, and connect one end to the meter terminal, where the orange wire was connected.

(8) Locate the red test lead, and connect one end to the free end of the 10 K resistor.

(9) Connect the opposite end of the red test lead to one side of R3' (opposite of where the black lead is connected).

(10) The meter should now show a positive (upward) deflection. If it shows a negative (downward) deflection, reverse the leads across R3'.

(11) Adjust R5 (located next to the ohms adjust) for a 1.8 volt reading on the 0-10 scale.

(12) Disconnect the test leads and the 10 K resistor.

(13) Resolder the orange and brown wires back on to the proper meter terminals.

(14) Adjust R2 until the meter reads 0.

Calibration is now complete.

GUARANTEE (applicable to factory finished units)

The Model 3000 is guaranteed to be free from defects in material and workmanship for 90 days from date of purchase by the original customer. To obtain guarantee service, return to Delta Products, Inc., accompanied by suitable receipt showing date of sale. Delta Products responsibility shall be limited to repair of any unit found defective in material or workmanship when returned prepaid to Delta Products.

This guarantee shall not apply to any unit which has been abused, improperly connected, or repaired by anyone other than the factory.

This guarantee is in lieu of all others, expressed or implied, including the warranty of merchantability and all other obligations and liability on Delta Products part, and neither assumes nor authorizes any person or company to assume for Delta Products any other liability in connection with the sale of Delta manufactured equipment.

MODEL 3000 PARTS LIST

Transistors

Q1, Q2, Q6, & Q7	2N3414
Q3, & Q4	2N5457 or MPF103
Q5, & Q8	2N3638
Integrated Circuit Operational Amplifier	LM-709-C

Resistors

R1 (Brown-Black-Orange-Gold)	10K ±5%
R2	5K Miniature Variable
R3	5K Ten Turn Variable
R3' (Brown-Black-Red-Gold)	1K ±5%
R4 (Yellow-Violet-Brown-Gold)	470 ±5%
R5	5K Miniature Variable
R6 (Brown-Green-Orange-Gold)	15K ±5%
R7 (Brown-Black-Yellow-Gold)	100K ±5%
R8 (Brown-Black-Red-Gold)	1K ±5%
R9 (Brown-Black-Orange-Gold)	10K ±5%
R10	5K Ten Turn Variable
R11 (Brown-Black-Orange-Gold)	10K ±5%
R12 (Orange-Orange-Red-Gold)	3.3K ±5%
R13 (Brown-Black-Brown-Gold)	100 ±5%
R14 (Brown-Green-Red-Gold)	1.5K ±5%
R15 (Brown-Green-Orange-Gold)	15K ±5%
R16	Selected Value
R17	Selected Value — Factory Selected and Installed
R18	1 ±1%
R19* (White-Brown-Gold-Brown)	9.1 ±1% - 1 Watt
R20* (White-Brown-Brown-Gold)	910 ±5%
R21 (White-Black-Black-Brown)	90 ±1%

NOTE: Parts may be marked with value instead of color coded.

* These parallel Resistors may be substituted by a 9Ω 1% resistor.

PARTS LIST CONT'D

R22** (Red-Green-Green-Brown)	2.5 Meg ±1%
R23 (White-Black-Brown-Brown)	900 ±1%
R24 (Brown-Black-Yellow-Gold)	100K ±5%
R25 (Red-Black-Red-Brown)	2K ±1%
R26 (Violet-Black-Red-Brown)	7K ±1%
R27 (Red-Black-Orange-Brown)	20K ±1%
R28 (Violet-Black-Orange-Brown)	70K ±1%
R29 (Red-Black-Yellow-Brown)	200K ±1%
R30 (Violet-Black-Yellow-Brown)	700K ±1%
R31 (Red-Black-Green-Brown)	2 Meg ±1%
R32** (Red-Black-Green-Brown)	2 Meg ±1%
R33** (Red-Green-Green-Brown)	2.5 Meg ±1%
R34 (Brown-Black-Orange-Brown)	10K ± 1%

Capacitors

C1	.01 mfd. 1 KV Ceramic
C2	.1 mfd. 400 V Mylar
C3	330 pfd. Ceramic
C4	20 pfd. Ceramic
C5	64 mfd. Elect. 64V

Diodes

D1, D2, D4, & D5	100V general purpose silicon (epoxy)
D6, D7, D8, & D9	1N4454 Silicon (Miniature glass)
D10	1N762 Zener Diode (Violet-Blue-Red)

Meter	200 ua Mirror Scale

NOTE: Parts may be marked with value instead of color coded.

** These resistors may be substituted by two 3.5 Meg Ω 1% resistor. (Orange-Green-Green-Brown)

PARTS LIST CONT'D

Miscellaneous

Function Selector Switch

Range Selector Switch

Input Circuit Board

Switching Circuit Board

Amplifier Circuit Board

Case Assembly

Range Selector Knob

Function Selector Knob

Ohms Adjust Knob

Zero Adjust Knob

Front Panel

Sub Panel

Battery Box

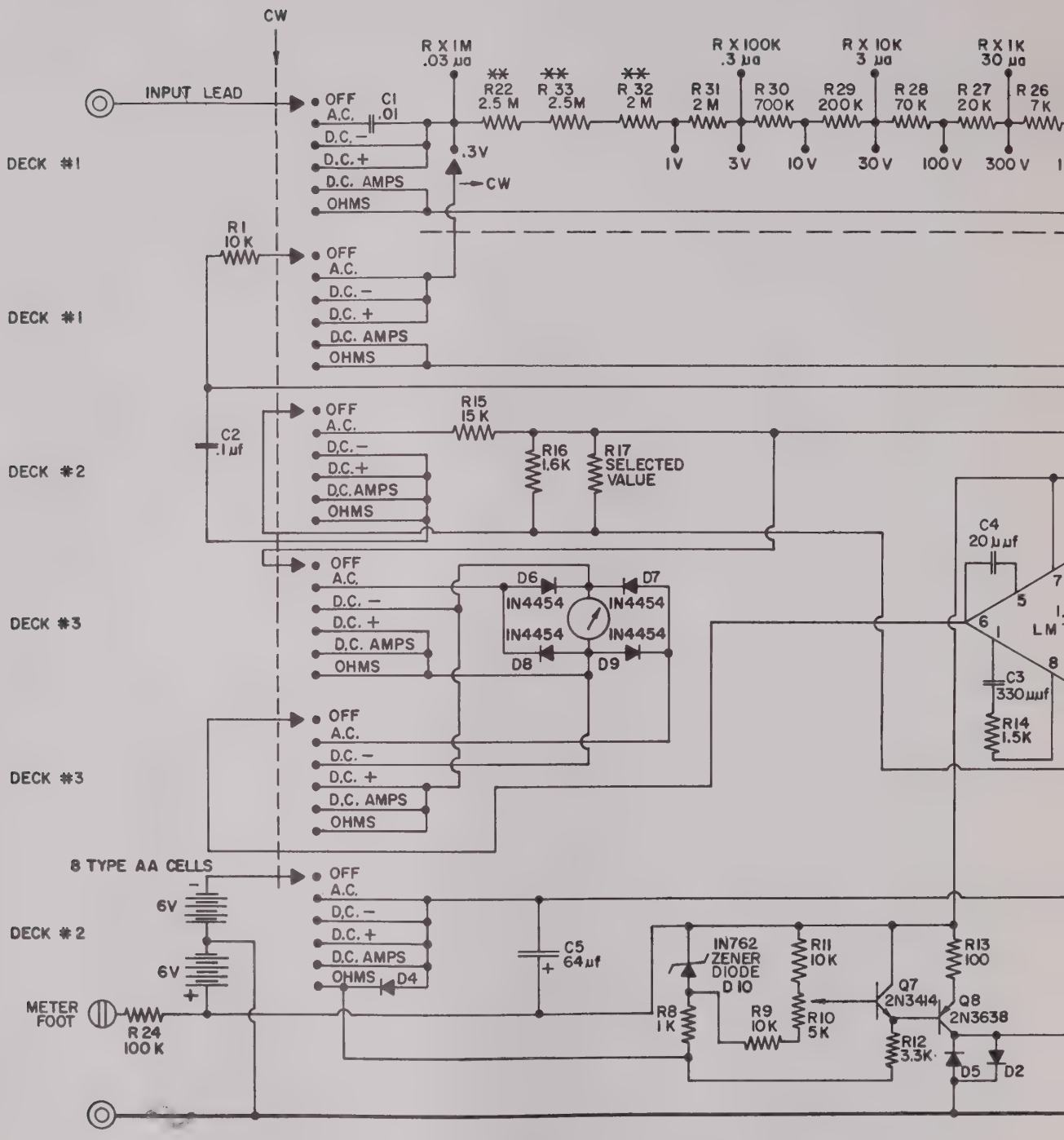
Input Jack and Hardware

Common Jack and Hardware

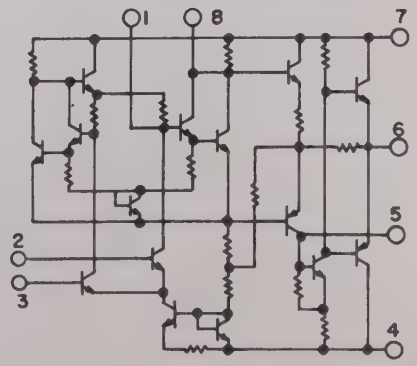
Probes

Wire

Solder

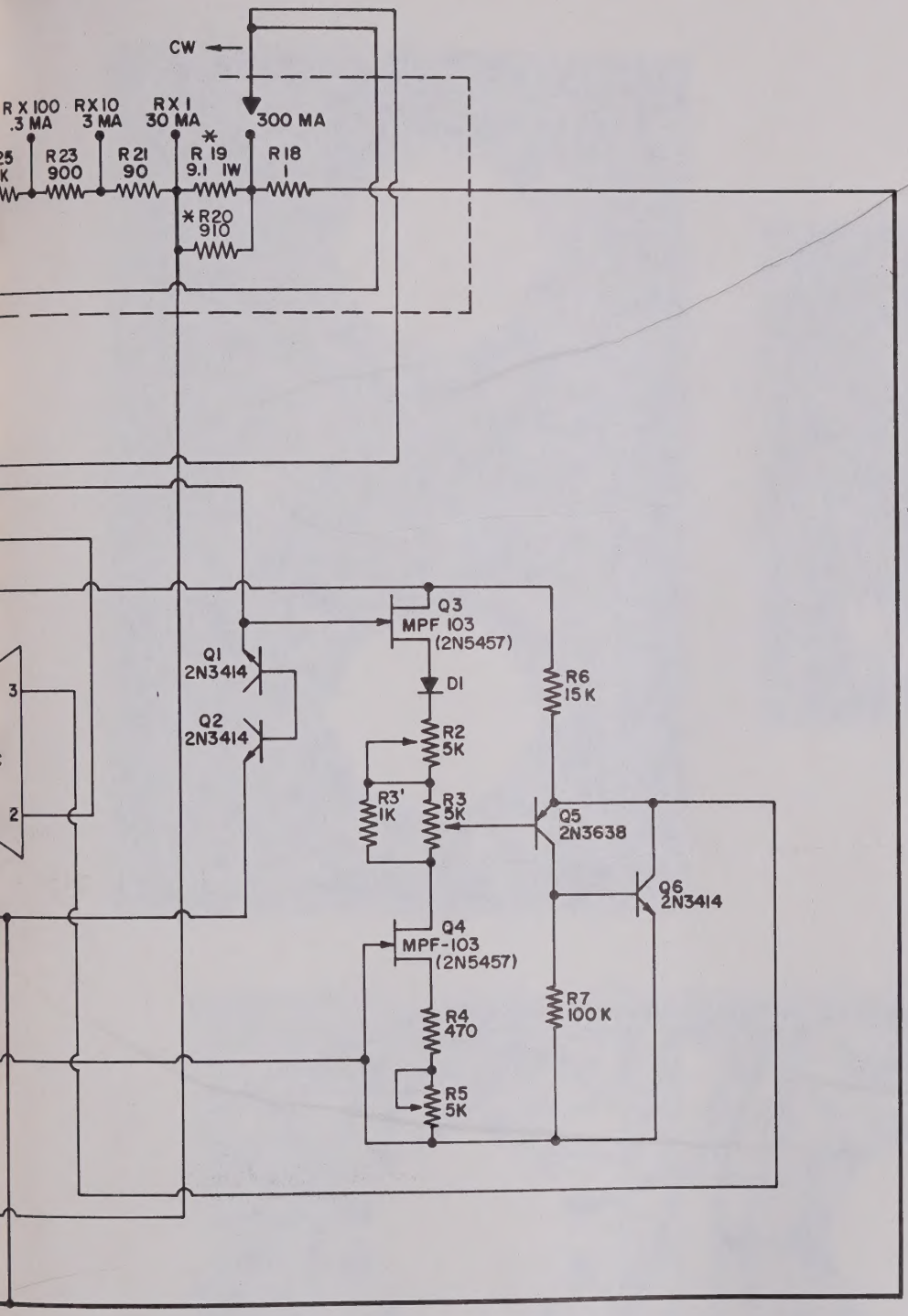


I.C. SCHEMATIC DIAGRAM

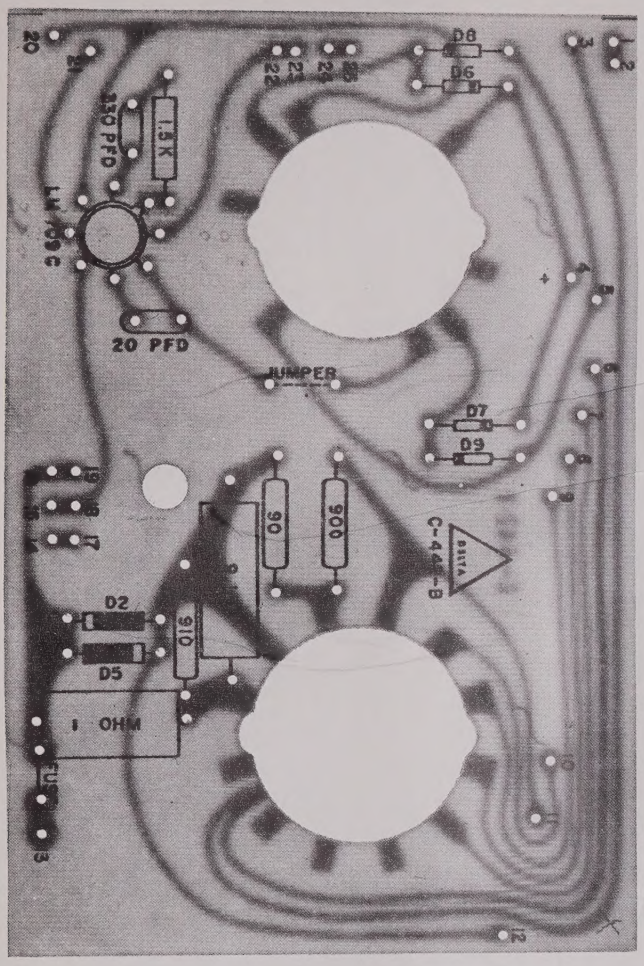


NOTE:

1) ✱= THESE PARALLEL RESISTORS MAY BE SUBSTITUTED BY A SINGLE VALUE 9 OHM RESISTOR
2) DIODES UNLESS OTHERWISE SPECIFIED ARE 100 V SILICON
3) Q4 SELECTED FOR SOURCE GATE VOLTAGE OF 0.8V MAX. AT 0.5 MA. THROUGH SOURCE.
4) ✱✱ = THESE SERIES RESISTOR MAY BE SUBSTITUTED BY TWO 3.5M OHM RESISTORS



SCHEMATIC DIAGRAM
FET V-O-M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D9
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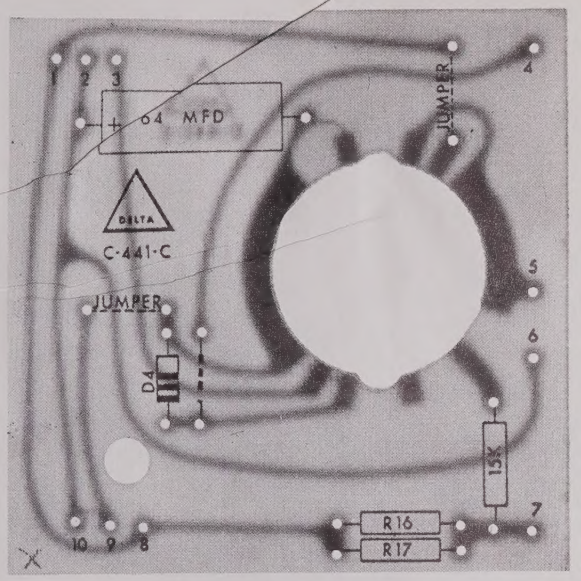
900
C-441-B
D2
D5
910
1 OHM
FUSE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D4
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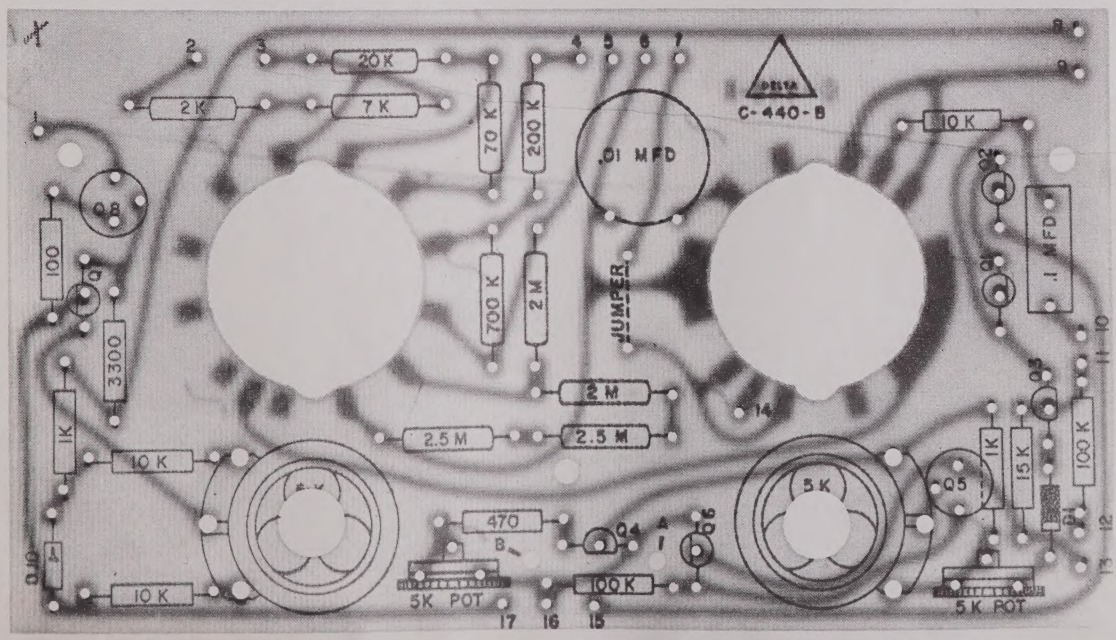
R16
R17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1K
700 K
2 M
JUMPER
2 M
2.5 M
2.5 M
10 K
5K
1K
15 K
100 K
470
100 K
10 K
5K POT
5K POT